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Mineralogy of Sediments from Lake Waiau, Hawaii[1]

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ABSTRACT: Fourteen sediment samples from Lake Waiau, a tropical alpine lake in Hawaii, were analyzed by X-ray diffraction for their mineral composition. Plagioclase is the major mineral; others are montmorillonite, goethite, and quartz. Plagioclase is derived from local tephra; montmorillonite and goethite are weathering products; and quartz is of eolian origin. A diagenetic mineral, vivianite, is also present.

LAKE WAIAU IS LOCATED in Waiau Cone (3980 meters) near the top of Mauna Kea on Hawaii Island (Figure 1). The lake, which averages 90 meters in diameter with a maximum depth of less than 3 meters, is an ideal natural sediment trap. Woodcock, Rubin, and Duce (1966) reported 7.5 meters of sediments present in the lake, which probably existed in Pleistocene time.

Two cores collected during 1966 have become available for analysis of their bulk mineral composition. The sediments of these cores consist of thinly layered, light-brown, olive-to-reddish silty clay interbedded with two black ash layers.

Semiquantitative X-ray diffraction analysis by the methods of Rex (1969) and Fan and Rex (1972) was used to determine the relative abundance of minerals. Fourteen samples from two cores were analyzed and results are presented in Table 1. Plagioclase and montmorillonite are present in all samples—plagioclase as the main constituent and montmorillonite as a minor constituent. Goethite is found in lesser concentration and occurs in only some samples. A small amount of quartz is found only at the top of the core.

Vivianite is found in the top 10-ft interval of a 12-ft core. The blue vivianite-bearing layer (1 mm) became apparent after the core was exposed to air. The X-ray diffraction pattern of the vivianite is almost identical to those listed in the powder diffraction file in Joint Committee on Powder Diffraction Standards (JCPDS 1960, Inorganic sets 1–5, p. 558 3–0070). The differences in some of the d-spaces of the vivianite from the JCPDS standard may be caused by variations in its chemical composition. It is nowhere abundant enough to be detected by whole-rock X-ray diffraction analysis.

Plagioclase is derived locally from tephra. Montmorillonite and goethite are weathering products of the tephra. Goethite probably formed from the alteration of olivine, magnetite, and pyroxene that derived from the tephra. Trace amounts of magnetite and pyroxene have been observed under the petrographic microscope. Hudnall and Jones (1976), in their study of the soils near Lake Waiau, also reported montmorillonite as the chief weathering product. Ugolini (1974) suggested that montmorillonite on the upper slopes of Mauna Kea could have resulted from alteration of the tephra by water released in the melting of the ice.

The presence of quartz, especially at the top of the cores, suggests eolian origin; its presence in the rest of the core is probably masked by the locally derived plagioclase and glass. Eolian quartz in the Hawaiian Islands and on the seafloor around the Hawaiian Islands is well documented by Rex and Goldberg (1958) and Rex *et al.* (1969).

The higher P_2O_5 (1.14 percent) and normative apatite (2.69 percent) content in the hawaiite from Mauna Kea as compared to other Hawaiian volcanic rocks (Macdonald and Katsura 1964) provides the phosphate needed for the formation of vivianite, and goethite provides the iron. A similar type of

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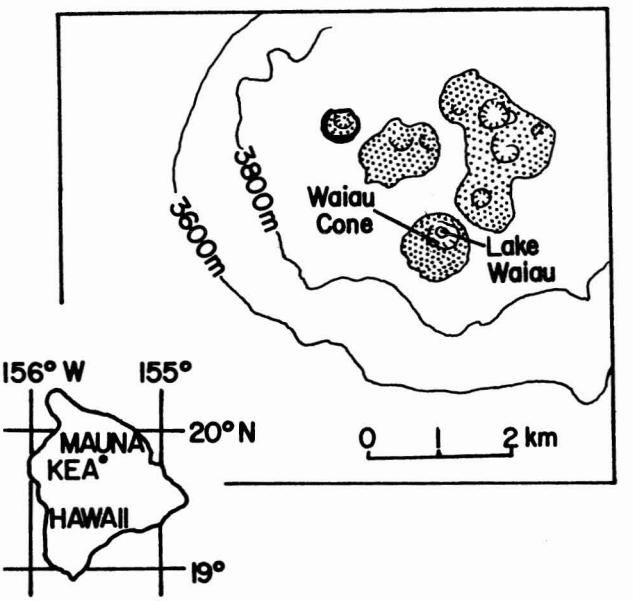

FIGURE 1. Index map of Lake Waiau and the pyroclastic cones (dotted) on the summit of Mauna Kea.

TABLE 1

MINERAL COMPOSITION OF SEDIMENTS FROM LAKE WAIAU

SAMPLE NUMBER	DEPTH OF CORE (cm)	MINERALS (WEIGHT %)			
		Plagioclase	Montmorillonite	Goethite	Quartz
1-1	14	83	7	8	2
1-2	33	92	8	—	—
1-3	37	97	3	—	—
1-4	54	64	10	26	—
1-5	74	92	8	—	—
1-6	96	88	12	—	—
1-7	106	84	16	—	—
1-8	107	91	6	3	—
1-9	119	88	12	—	—
1-10	132	86	7	7	—
1-11	136	84	9	7	—
2-1	22	78	3	9	3
2-2	36	80	14	6	—
2-3	179	92	8	—	—

lacustine vivianite has been reported by Rosenqvist (1970) in the Holocene clay sediments from Lake Asrum, southeastern Norway.

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LITERATURE CITED

FAN, POW-FOONG, and R. W. REX. 1972. X-ray mineralogy studies, Leg 14. Pages 677–726 *in* D. W. Hayes *et al.* Initial reports of the deep sea drilling project. Vol. 14. U.S. Government Printing Office, Washington, D.C.

HUDNALL, W. H., and R. C. JONES. 1976.

Weathering products of recent volcanic ash and cinders on the island of Hawaii. Page 27 *in* Influence of age and weathering environment (abstract). Program and Abstracts, 25th Clay Mineral Conference. The Clay Minerals Society, Corvallis, Oregon.

JOINT COMMITTEE ON POWDER DIFFRACTION STANDARDS. 1960. Powder diffraction file sets 1–5 (revised). Inorganic volume. Joint Committee on Powder Diffraction Standards, Philadelphia, Pa. 685 pp.

MACDONALD, G. A., and T. KATSURA, 1964. Chemical composition of Hawaiian lavas. J. Petrol. 5:82–133.

REX, R. W. 1969. X-ray mineralogy studies, Leg 1. Pages 354–367 *in* M. Ewing *et al.* Initial reports of the deep sea drilling project. Vol. 1. U.S. Government Printing Office, Washington, D.C.

REX, R. W., and E. D. GOLDBERG. 1958. Quartz content of pelagic sediments of the Pacific Ocean. Tellus 10:153–159.

REX, R. W., J. K. SAYERS, M. L. JACKSON, and R. L. CLAYTON. 1969. Eolian origin of quartz in soils of Hawaiian Islands and in Pacific pelagic sediments. Science 163:277–279.

ROSENQVIST, I. T. 1970. Formation of vivianite in Holocene clay sediments. Lithos 3:327–334.

UGOLINI, F. C. 1974. Hydrothermal origin of the clays from the upper slopes of Mauna Kea, Hawaii. Clays Clay Miner. 22:189–194.

WOODCOCK, A. H., M. RUBIN, and R. A. DUCE. 1966. Deep layer of sediments in alpine lake in the tropical mid-Pacific. Science 154:647–648.